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Forestry Research West

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

Forestry Research West

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Despite the crash of the Heli-Stat airship last July, the USDA Forest Service has not lost interest in using airships and helicopters for yarding timber. Scientists at the Pacific Northwest Station have developed a computer model that permits a comprehensive look at timber harvesting operations and offers information on what could become a new way of evaluating and coordinating all aspects of timber harvesting. Here, a helicopter is being used in validation tests where logs are weighed on the scales at left. Read more about this exciting research on page 1.

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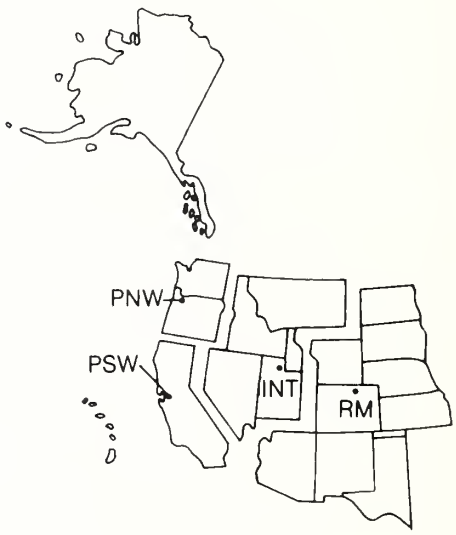

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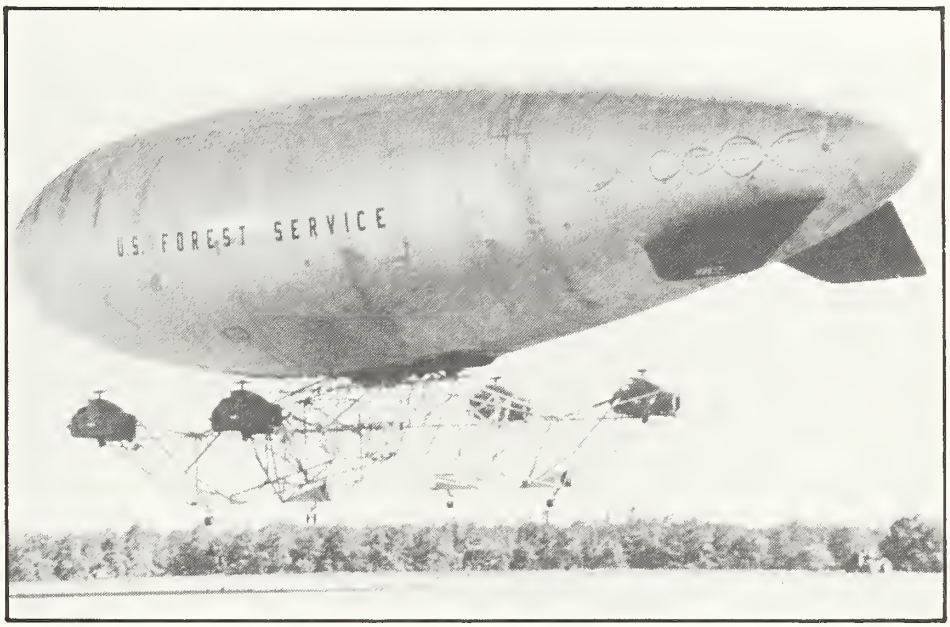
The heli-stat legacy: A new model for timber harvest planning

by Dorothy Bergstrom
Pacific Northwest Station



The Heli-Stat during hover test in New Jersey July 1, 1986, just before it crashed.

Preparations by Forest Service researchers to evaluate an airship for possible use in yarding timber have produced an unexpected bonus: a computer model that permits a more comprehensive look at timber harvest operations than has been possible in the past and provides the foundation for what could become a new way of evaluating and coordinating all parts of the timber harvest operation.

The model was developed under the direction of Engineer Michael Lambert of the Pacific Northwest Station in his capacity as program analyst for evaluation trials of the Heli-Stat, the prototype yarding airship that crashed and burned in July 1986. Initial plans were to bring the Heli-Stat to the West Coast and evaluate its aerodynamic performance in logging trials.

The Heli-Stat, consisting of an aerostat (balloon) attached to four helicopters, was intended to demonstrate the feasibility of ferrying logs from remote roadless areas in larger loads, over longer distances, than has been possible with other yarding methods.

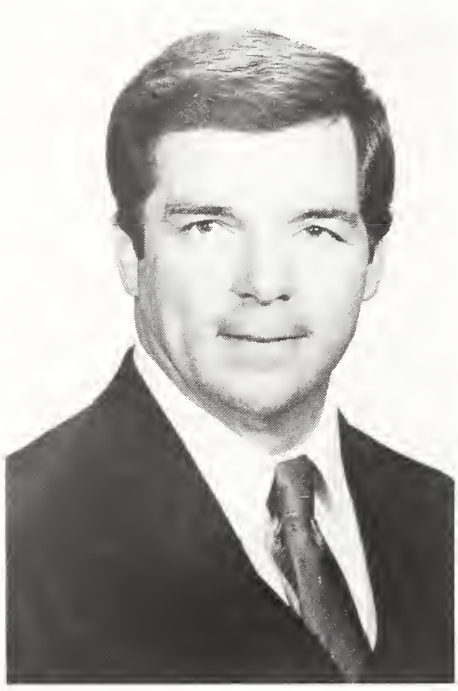
Although the testing opportunity was lost along with the Heli-Stat, the investment in planning for the evaluation was not; a computer submodel is now available for evaluating the aerodynamic capabilities of the next generation of yarding airships. Perhaps more important, a new planning simulation model provides the conceptual framework for integrating data from many sources, including existing timber harvest models. Although it is oriented to airship and helicopter yarding, the model provides a common basis for comparing a range of combinations of timber harvest processes, from initial planning to reforestation. It is based on information from specific situations—not on averages. When supplied with information about a particular logging operation, the model can help the planner, logging engineer, or logging operator identify the combination of equipment, workers, and procedures that will achieve the greatest productivity at the least cost.

Evaluating an airship for logging

In 1981, Lambert was given an assignment: analyze the technical and economic feasibility of logging with large airships; develop methods for estimating the weight of logs and trees; and prepare for field trials of the Heli-Stat.

The assignment meant translating into reality the intriguing idea of an airship lifting logs out of otherwise inaccessible timber stands. It meant examining every detail of what would be a new type of timber harvest operation. It required not only describing the capabilities needed in an airship that could yard timber efficiently; it meant anticipating how the usual logging operation would be changed. In addition to new possibilities, yarding with an airship would introduce new requirements for support equipment and workers.

Although a major problem was to find an efficient method for assembling loads of logs for lifting by the airship; there would be other considerations. For one thing, workers would need to get to the logging site. For another, landings would have to be bigger to accommodate not only the airship but all the equipment needed for its support. Some operations might be done better at locations other than the usual ones. For example, if it became feasible to ferry whole trees from the logging site, bucking and delimbing could probably be done more efficiently at the landing.



Mechanical Engineer Michael Lambert

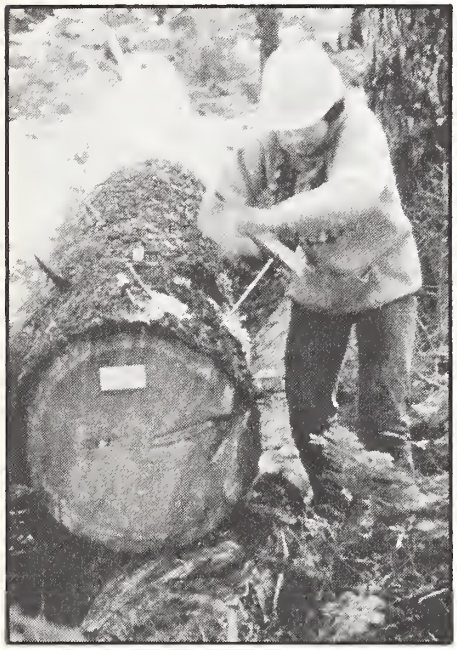
Assembling loads would require accurate estimates of log weight—made in the field. It would also require a machine to move trees and logs on steep slopes. Crawler tractors, rubber-tired log skidders, and other conventional skidding equipment cannot maneuver well enough on steep slopes, or are likely to cause serious soil disturbance or other environmental damage.

Processing large turns of logs and trees at the landing, without delaying the airship, would mean figuring out the rates of all steps in log handling. How, for example, would frequency of turns affect the type of equipment and number of workers needed at the landing? How would distance between the cutting area and the landing affect the arrival times of turns?

In short, it would be impossible to evaluate the performance of a logging airship without both visualizing the complete operation and examining each step in detail to find out how it relates to and affects all the other steps and their costs.

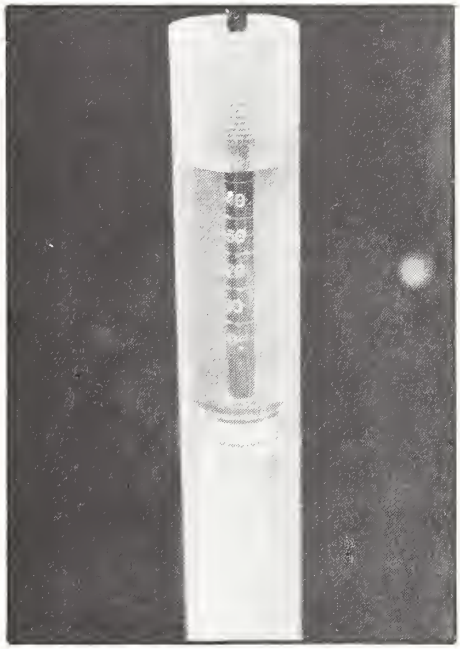
Because logging equipment is expensive to own, operate, and move around, Lambert decided to figure out as much as possible in the office before any trials on the ground or in the air. Doing this would also avoid setting up support equipment by trial and error, risking expensive delays, and possibly having to run tests more than once.

To do this complicated job in the short time before logging trials were then scheduled for the West Coast, Lambert decided to use the computer to simulate all steps in the aerial logging operation. This meant using the computer on a broader scale, with more precise data and greater emphasis on weight, than previous computerized logging routines had required. There were no simulation models that could be used or extrapolated to project the performance of large airships. Much of the earlier logging planning had been based on averages, past experience, and rules of thumb.



Green density is measured at the logging site with a portable xylodensimeter invented by Gary Bergstrom, Rogue River National Forest. (1) Cores are taken at various heights from

several sample trees. (2) Each core is trimmed to a fixed length, with the correct proportion of sapwood to heartwood, and inserted into a calibrated hydrometer. (3) The height at which



the hydrometer floats in distilled water indicates the density of the green wood.

LOGPAC: A conceptual formulation

LOGPAC (for Logging Productivity and Costs) is the name of the model that began as a way to describe the aerodynamic performance required of a logging airship but expanded to provide the framework for a family of submodels that together express mathematically all phases of logging, from sale preparation to slash treatment and reforestation. The model provides the framework for accomplishing two important functions: (1) simulating the performance of an aerial vehicle with the desired features and capability before it is built, and (2) comparing the productivity and costs of different logging plans, regardless of yarding method.

LOGPAC offers a systematic, uniform, reliable method of tracking productivity and costs. It provides a standard means of communicating about logging production and costs by people of different backgrounds and roles in the timber harvest operation.

The advantages of LOGPAC over other planning and accounting methods are: (1) It figures productivity and costs on the basis of the logs being handled, on a specific site, under the environmental conditions at hand, by machines and people whose performance is quantified. Productivity and costs are not based on average values. (2) It contains a simulation clock that makes it possible to analyze the effects of relative production rates on successive activities, so material handling will flow efficiently, without expensive bottlenecks. (3) Data the user supplies are standardized but flexible; they can be easily modified and improved. (4) Numerous analyses can be made and compared by making simple changes in the input data. (5) The model contains automated reminders for the user and makes sure that all items are considered in the same way for each analysis.

How the model works

A person using the model carries on a dialogue with the computer. The first step is to supply data from the timber cruise on the size and number of trees in a cutting unit.

The model then asks what log lengths are preferred, what is the maximum weight, and which is the more important constraint.

After getting this information, the model will "cut" all the trees into logs (unless whole-tree yarding is selected), report the length and weight of logs in each tree, and recommend a bucking strategy. It will tell how many pieces are to be yarded and how many trips the yarder will have to make. It will also tell how long felling will take with a given number of fallers.

The dialogue continues through a series of questions and answers that cover the range of details about the operation, down to and including such items as the cost of owning the logging equipment (investment, depreciation period, taxes, insurance) and weather (altitude, wind speed and direction, temperature, humidity) at both the loading and landing sites.

Based on information and relationships built into the model and data added by the user, the computer simulates, integrates, and reports on all phases of the logging operation, finishing with a summary of costs, tons of logs removed, and the bottom line—cost per ton of product.

Following are examples of the type of information the model will report when yarding is done aerially:

— Total number and weight of logs in the harvest unit
— Time and pounds of fuel used per turn, based on airship configuration, load weight, and flight profile
— Number of turns per refueling cycle
— Number of fuel cycles per harvest unit
— Payload per turn, number of probable aborts, and overall load factor (actual weight carried divided by theoretical carrying capacity)
— Weights of unmerchantable residue (bole and crown)
— Number of days needed to harvest the unit
— Ownership and operating costs for each activity and for the total operation

How the model can be helpful

One big advantage of computer simulation is that it allows the user to check out all components of a timber harvest operation and identify potential bottlenecks before logging begins. The size of potential backlogs aids logging planners in specifying sizes of equipment, crews, and landing areas to increase production and reduce costs. In aerial logging, for example, queues of logs may build up on the landing as a result of differences in turn arrival times, crew sizes, and production rates. Such backlogs may suggest shifting idle time to less costly equipment; queues on the landing may be preferable to delays for the airship.

Another comparison that is important to simulate when yarding is done by air is the cost of transporting workers to and from the logging site. If the fallers and choker-setters must be flown by helicopter to their work site, one set of commuting expense based on distance is used; if they go by truck and walk part way to the harvest site, the expense is probably different.

Simulation also permits examining the advantages and disadvantages of landing sites. The costs of driving log trucks can be compared with yarding costs for different locations. The effects of changing the driving or yarding distance a few miles, or a few hundred feet in elevation, are easily identified.

LOGPAC can help a planner use existing equipment to the best advantage. It can become a comprehensive spread sheet that shows how changes in any part of the system affect other parts. For example, it can indicate the effects of down time and other delays and illustrate how stretching out a job increases costs. It can project costs in relation to the amount of product produced and help the planner relate production costs to expected market values and risk. Perhaps most important, it can make comparisons and help identify the logging system that will minimize costs.

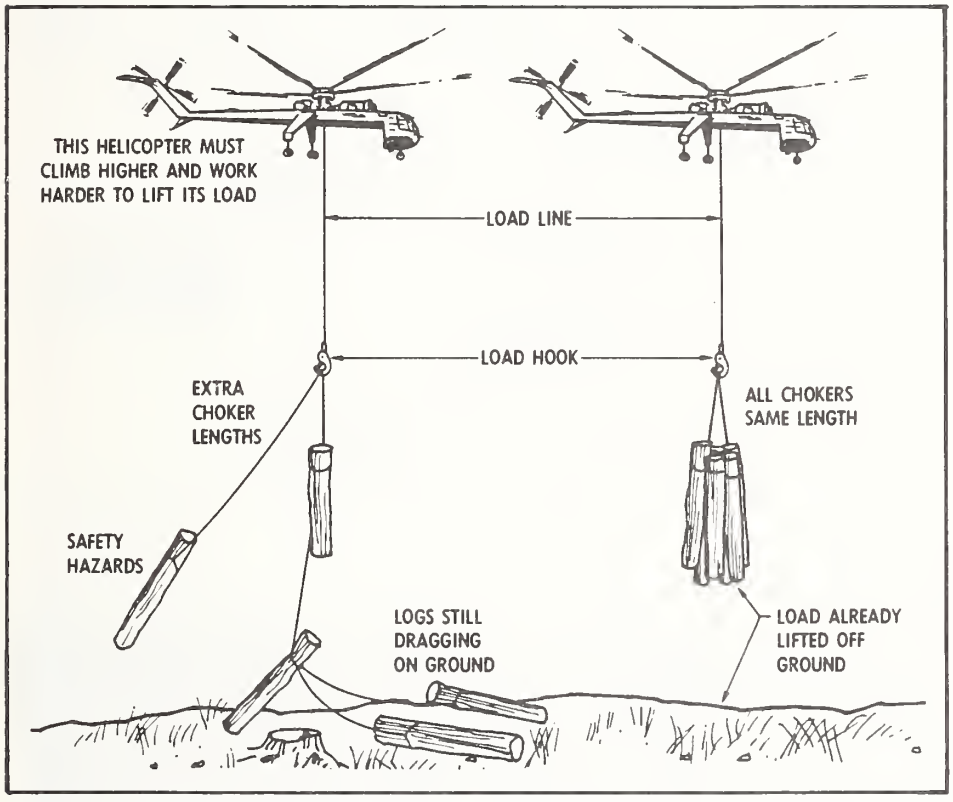
Flexibility is built in

LOGPAC is a generic model, capable of expansion, change, and refinement. The user can change any item and substitute better information. For example, the cost per hour of owning and operating a front-end loader or its production rate can be entered as known data, or as a calculating submodel inserted when better information becomes available or conditions change. Models already available for different types of equipment can be incorporated as, for example, a software program for skidder yarding.

Users can also adapt the LOGPAC family of models to different data processing systems and provide new productivity algorithms or their own cost accounting subroutines.

Where the subroutines and data in model came from

In developing LOGPAC, Lambert pulled together information already available from a number of sources, some of it from the Pacific Northwest Station. Other Station scientists and several cooperators assisted in conducting individual field studies on activities for which data were lacking.



Using chokers the same length saves time, fuel, and money over using chokers of different lengths. Less energy is required to drag the logs free of the ground, less vertical ascent is required to clear the ground, there is less aerodynamic drag, and load-release is quicker at the landing. This method requires pre-bunching turns before yarding. LOGPAC simulation reveals how one such improvement in efficiency affects the overall efficiency of a logging operation. Planners can analyze the costs and benefits of different processing steps.

Cooperators included Intermountain Station, the Pacific Northwest and Pacific Southwest Regions of the Forest Service, Montana State University, University of California, and Oregon State University. Technical assistance with the computer studies for the aerodynamic performance model came from a private aerospace firm.

Estimating weight

The foundation of LOGPAC is information from the timber stand and the weight estimating routine. Weight assumes vital importance in aerial yarding. If the equipment is not used to capacity, the operation is more expensive than necessary; if the equipment is overloaded, loads will be aborted, wasting time and adding to costs.

Research at the Pacific Northwest Station has produced methods for estimating tree and log volume and developed related tools and computing capability to support methods of estimating weight in the field. This research involved taking trees apart and weighing the parts after they were graded in size classes. It also used a device to measure green density that was invented by a Forest Service employee in the Pacific Northwest Region. The result is a submodel that can predict the weight of logs and recommend bucking strategies that will optimize the number of preferred length logs within the constraints of equipment and handling capabilities.

The number and sizes of logs to be handled form the basis for simulations of the number of workers needed and their production rates. Other studies provided information that helps quantify the most efficient and cost-effective combination of people, equipment, and operations, based on costs of assembling loads, lifting and transporting loads, and handling logs at the landing—all expressed in costs per ton of yarded logs.

Validation trials

The data in most of the submodels were validated and quantified in several logging operations in Oregon and California between May 1981 and November 1983.

The most recent trial was a logging operation on the Rogue River National Forest in late 1983 that was planned as a dress rehearsal for the Heli-Stat evaluation. The yarding vehicle was a large helicopter. Data collected were used to validate the helicopter part of the airborne performance model. The trial also built confidence in the validity of the model as an approximation of the yarding capacity of an airship that combines an aerostat with one, two, or four helicopters.

Tests on the Gifford Pinchot National Forest in 1982 and the Mount Hood National Forest in 1983 validated the log weight estimating methods that were developed during studies on the Wind River Experimental Forest in 1981-82. Other validation studies included: load factors on the El Dorado National Forest, load assembly methods for small timber on the Gallatin National Forest, landing operations on the Rogue River and

Olympic National Forests, and production rates for the Spyder (the machine for assembling logs on steep slopes) on the Olympic National Forest.

Present status of the model

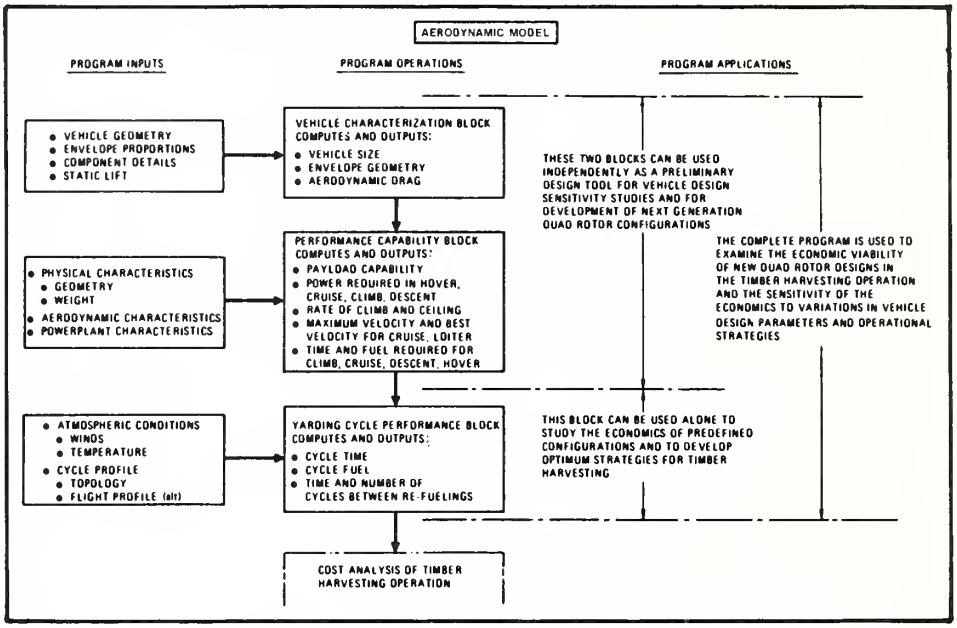
In its current form, parts of the model are ready to analyze harvesting systems and help agency people protect costs and help bidders come up with realistic bid prices. Not all submodels have been validated. With a little more work, there could be routines for other operations—skyline yarding, for example.

Lambert says the model needs to be refined as people use it with different species of timber, under varied environmental conditions, with new types of equipment, or new configurations of machines and workers.

One of the improvements needed is to incorporate road costs. The framework for adding these is in place. If the purpose of yarding with an airship or helicopter is to reach places where it would be difficult or environmentally unacceptable to build roads, then adding the cost of building and maintaining roads to the economic evaluations will give a clearer picture of the cost of various types of aerial yarding.

LOGPAC can also evaluate ways of treating fuel or residue and plans for multi-product marketing.

Lambert has made practical use of the model. For example, in June 1986 it was used to help evaluate a salvage sale in a municipal watershed on the Mount Hood National Forest. The sale was designed as a two-stage operation—part helicopter, part cable—to protect water quality. But there were no bids on the sale until after LOGPAC was used to analyze the costs of various new combinations of logging processes and slash treatment that were proposed.



This drawing illustrates how the LOGPAC aerodynamic model opens up a new frontier in planning. It permits manipulation of the design features of an aerial yarding vehicle before it is built and shows how the performance capabilities of various design configurations would translate into economic factors—the fuel and time required to yard a given amount of timber.

Lambert expects that a yarding airship will be developed within the next few years. In fact, two are currently in the flying prototype stage in the United States. In other countries, there is a good deal of interest in aerial vehicles for moving people, ship cargo, and prefabrications. Machines are being developed in Russia, Japan, Great Britain, Germany, and Canada.

Lambert has written about evaluating airships for yarding and about the family of models. For reprints of the following journal articles, write Michael B. Lambert at the Pacific Northwest Station or call him (FTS 423-2030; or 503/231-2030). Reprints available include: *Development and trials of a heavy-lift airship used for logging*, ASAE Pap. 81-1585, In Proceedings, Winter Meeting, American Society of Agricultural Engineers, 1981; *Airship logging: parameters affecting load factors*, In Transactions of the ASAE, Vol. 28, No. 5, pp. 1363-1366 and 1370, 1985; *Modeling load assembly methods for helistat logging*, In Transactions of the ASAE, Vol. 26, No. 2, pp. 357-362, a983; *Simulating changes to helicopter logging operations*, In Transactions of the ASAE (in process); *Optimizing productivity, costs, and products through complete harvesting planning*, In Proceedings, 1986 Council on Forest Engineering Annual Meeting, (in process).

Several Station publications describe studies that contributed information incorporated in the model. For copies of the following, write to Publications, Pacific Northwest Station: *Estimating tree bole and log weights from green densities measured with the Bergstrom xylodensimeter*, Research Paper PNW-322, 1984; *Wood density-moisture profiles in old-growth Douglas-fir and western hemlock*, Research Paper PNW-397, 1986; and *Estimating the weight of Douglas-fir tree boles and logs with an iterative computer model*, Research Paper (in press).

A new program for riparian research

by Mike Prouty
Intermountain Station

"What would you do with a riparian, if you could catch one?" Personnel of the Intermountain Research Station's new riparian research program often begin talks to civic and community groups with such a question—recognizing that their research topic isn't exactly a household word.

Although the term may not be well known, many public resource managers in the West believe that conflicts surrounding the management and use of the productive and sensitive land adjacent to lakes, streams, seeps, and springs is—next to timber management—the most potentially explosive land management issue of the day.

New information resulting from the Riparian-Stream unit will lead to livestock grazing regimens that ensure protection of riparian areas on public land.

Where water is king

Water is the lifeblood of the vast country lying West of the 100th meridian. It didn't take long for the pioneers to understand the crucial importance of water in the arid West. Where springs, streams, and lakes were found, so was lush vegetation that provided food and shelter for a variety of critters, large and small. By claiming ownership of a few key acres of springs or along streams, an individual exercised de facto ownership of thousands of surrounding acres. No wonder then, that the range wars between ranchers, Indians, and farmers often involved access to water and control of irrigation rights.

Although the days when disagreements were settled with a 6-shot revolver are history, conflict over, and abuse of, riparian areas has continued to the present. Human activity in riparian areas—including home building, crop production, road construction, mining, timber harvesting, and grazing—has jeopardized the ability of these areas to provide all the things demanded of them.

Although over 90,000 miles of streams and rivers on land administered by the Forest Service and the Bureau of Land Management (BLM) provide nearly 3 million acres of riparian-stream areas, there simply isn't enough to go around. Man depends on these acres to provide:

- water for cities and towns
- water and forage for livestock and wildlife
- quality shade and shelter for livestock
- prime habitat for birds and other wildlife
- fish habitat
- preferred locations for recreation activities
- an important part of the "scenic" value of western landscapes.

Destructive chain reaction

Riparian areas are complicated natural systems that haven't held up well under the pressure of these conflicting uses. Streambank vegetation provides an important stabilizing factor in riparian areas. This plant cover, and the bank itself, can be damaged in a number of ways—including excessive livestock grazing, off-road vehicle use, and even by excessive trampling by fishermen. Often one destablizing factor sets in motion a series of events that all lead to the same result—loss or degradation of the riparian area.

The destruction of a streambank by overgrazing leads to reduced fish habitat, poor forage, and loss of wildlife habitat.

When vegetation on a streambank—or the bank itself—is damaged, several changes can occur. Composition of the streambank plants can change or the amount of vegetation can diminish, resulting in a loss of shade and nutrients for the stream and a reduction in fish habitat. As vegetation is lost, so are soil-holding roots, making a streambank more unstable. With weakened banks, a stream is likely to flex its muscle in several ways—all with negative consequences.

Streams can begin bank cutting, thus becoming wider and shallower. Or streams can begin to scour the channel, making the streambed deeper than the surrounding area. This causes the water table in the adjacent riparian area to drop—with drastic consequences for existing vegetation. Whether streams move sideways or downward, the result is the same—poor water quality, reduced fish habitat, or poor range conditions. Nation-wide, over 80 percent of these areas have been altered. In the West, hundreds of thousands of acres of what were once lush riparian areas now support only sagebrush and other dry site plants—a result of disturbed stream systems and resulting lowered water tables.

Addressing the problem

The Intermountain Station has responded to the growing interest and controversy over competing uses for riparian areas. The new "Riparian-Stream Ecology and Management" research work unit, based at the Forestry Sciences Laboratory in Boise, ID, is chartered "to improve the understanding of riparian and stream habitats and improve methods of managing them for the conservation of resources and production of livestock, wildlife, and fish."

The project leader for the unit is range scientist Warren Clary. Other members of the unit include research fisheries biologist William Platts, wildlife biologist Dean Medin, botanist Nancy Shaw, fisheries biologist Richard Torquemada, range technician John Kinney, and part-time help from economist Fred Wagstaff.

The new unit will build upon a foundation of work established during 10 years of research by Platts. Platts pioneered the study of riparian-stream ecology. Establishing research plots in Nevada, Idaho, and Utah, he studied the effects of damaged riparian areas on fish production. His work has provided evidence that livestock grazing, road construction, timber harvest, and mining in riparian areas can reduce the capacity of streams to produce fish. When these streams occur within the headwaters of the Columbia River system, and represent critical spawning and rearing areas for salmon and steelhead, the impact of damaged riparian areas can be severe and far reaching.

With the concentration of expertise from a variety of scientific disciplines now focused on this issue, the new unit has become a center of Forest Service riparian research. Members of the unit bring different perspectives to bear on a variety of aspects to the problem. In response to the recreational values of nongame wildlife, Medin will use his wildlife background to study how livestock grazing in riparian areas affects the habitat of small mammals and birds.

Fisheries biologists assess and describe the conditions conducive to productive aquatic habitat.

Shaw will utilize her botany training to develop handling and planting techniques for woody plants such as willow, cottonwood, and alder. These species can help rehabilitate damaged riparian areas, by helping stabilize streambanks, by providing shade and shelter for wildlife, and by furnishing organic material to streams. Wagstaff provides an important economic focus to the problem of competing uses on riparian areas. He'll address such questions as, "How many added recreation days of fishing justify the expense of fencing a stream?" He'll also study the cost effectiveness of various management practices and techniques.

Their combined talents will address these research objectives:

—improve knowledge of the structure and function of riparian-stream ecosystems—including fish and wildlife—so that improved management practices can be developed,

—develop a scientific basis for cost-effective rehabilitation practices on riparian areas,

—develop improved grazing management methods,

—determine the effects of sediment on fish.

The project will not be without help. According to Clary, the National Forests and the BLM will be important partners in the work of project personnel. "We have worked closely with National Forests in Idaho and Nevada, and with BLM folks in Idaho, Nevada, and Utah in establishing numerous study plots."

The Pacific Northwest Research Station and the Rocky Mountain Forest and Range Experiment Station also have riparian studies under way. In addition to the Forest Service, several universities are conducting riparian research, including the University of Nevada-Reno, Oregon State University, the University of Wyoming, and Montana State University.

Walking the fine line

Clary and his associates must be careful to keep from becoming identified with the interest groups contesting use of riparian areas in the West. The main conflict boils down to ranchers—who want to continue to graze livestock on public lands—versus environmental and wildlife groups—who see the impact of livestock on riparian areas as reason for eliminating livestock grazing on public lands.

While the emphasis of the research work unit is related to the effects of grazing on riparian areas (as opposed to other impacts such as urban development, road construction, or timber harvesting), Clary wants to avoid involvement in the emotional debate surrounding the issue of grazing on public lands. "The best contribution we can make," says Clary, "is to provide unbiased, biological facts about the ecological function of these areas, so land-use policy and management practices can be based on sound information about the resource, not on emotion. I want our program to provide credible facts that have a positive influence on natural resource management."

Project personnel will use interim reports to transfer information resulting from their studies to resource managers, interest groups, and community organizations. "We think it's important to get the facts out quickly, especially in a situation where feelings run high," says Clary. "So while we'll go through the careful review process associated with technical research publications, we also want to release periodic 'progress reports' as new information is developed. This is an important way we can contribute."

No two alike

One problem facing the group is the variability of riparian areas. Some areas are extremely tough and durable—able to withstand heavy use by man and his animals with little damage to streambanks, loss of forage and wildlife cover, or reduced fish production. Other areas are very fragile, and will be severely damaged by even moderate use. Some areas recover quickly from impacts, others will show the scars of disturbance for many years.

"Because riparian areas are not all alike, we simply can't generalize our research findings," says Clary. "We need to establish study plots on many different sites to develop a feel for the range of conditions—and then we can develop associated management practices that apply in different settings."

Why the variability? The structure of streams varies—from small, fast-moving, relatively straight streams, to larger, older, slower-moving, meandering streams. Some streams run through highly erodible material while others lie on very hard, durable rock. In addition, the character of streams and riparian areas is influenced by topography, soil types, weather patterns, and vegetative cover.

Useful information

With their research mission established, personnel in place, problems selected for study, and action plans written, the unit has set out on an aggressive 5-year program of work. Studies are being designed to provide information regarding different types of riparian areas. But what specifically will result from this work?

"After we understand more about what's going on in riparian areas—how the various components of water, soil, topography, weather, animals, and plants interact—then we can devise management practices to ensure that man's activities won't damage the system," explains Clary.

Clary stresses the practical application of the work. "We want to develop an understanding of when, where, and how grazing of riparian areas is appropriate. With this knowledge, managers can develop guidelines for livestock grazing specific to their unique situations. Research by Bill Platts will tell us what the effect of sediment will be on fish populations. Finally, we want to develop cost-effective ways to repair and restore riparian areas that are damaged."

Debate over the use of riparian areas is likely to continue. The demand for water, grazing, fish production, and wildlife habitat will increase. But because of the attention Clary and others are focusing on these areas, the future of riparian areas—and all that they mean to the West—looks brighter.

Hurdygurdy—California's first basin-wide study of fish habitat

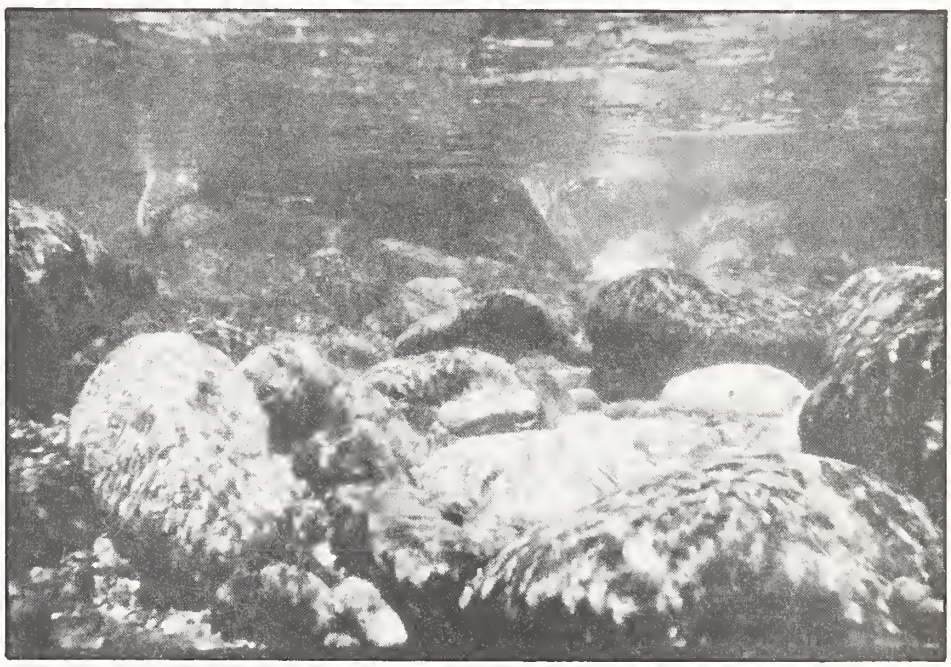
by R.B. Pearce, for Pacific Southwest Station

Current studies on the habitat likes and dislikes of fish should help forest and fishery managers alike. Results should enable them to maintain and perhaps even boost the populations of steelhead trout and Chinook salmon in Northern California's streams. Habitats the fish prefer, either for egg-laying, shelter, or feeding, could then be protected or new ones provided where none exist presently. But first, biologists and geomorphologists must correctly identify those habitats these commercially important fish covet and why.

Although researchers from the Forest Service and other agencies have been conducting year-round, basin-wide habitat studies in Oregon, Washington, and British Columbia for some time, only a few studies, most of them restricted to small reaches explored only in the summer, have been carried out in California. At the southern limit of the range of anadromous salmonids in North America, California's climate with large winter storms and hot, dry summers limits survival of fish in streams. The combination of climate, logging, erodible landscape, and intense fishing is likely to have a unique and strong impact on fish productivity and survival. That's why scientists from the Pacific Southwest Station's Redwood Sciences Laboratory in Arcata have launched a two-part study along a 12.5 mile channel in the Klamath Mountains. One part will relate the various types of habitat in the stream to the distribution and abundance of anadromous fish; the other will seek to discover whether physical and geological characteristics in and around the channel can be used to predict the frequency and total size of habitat types.

The study is under the direction of Hydrologist Thomas E. Lisle, and Fisheries Biologist Lynn M. Decker, and is scheduled to run at least for the next few years and probably longer.

Fish are directly observed underwater using snorkel and mask to learn their relative preference for different types of habitats.



The goal: To maximize fish habitat

According to Lisle, coordination of research of anadromous fish habitat originated in 1976 when a group of forest researchers and managers saw the need to learn more about how natural habitat affects fish reproduction and survival. Such research should have many practical benefits, they reasoned. For one thing, the physical enhancement of the stream environment might prove an effective way of maximizing habitat availability. The placement of boulders, weirs, woody debris and other structures, for instance, may significantly increase a stream's productivity by providing more pools, side channels, and other habitats in which fish thrive [See Sidebar: *Debris—Not the Menace Once Thought*]. The alternative—artificially propagating fish into a system—though a direct solution to the problem of dwindling populations, is costly and the outcome uncertain when variables relating to habitat are poorly understood.

In round-table discussions with state and Federal researchers and forest managers in 1982 and 1983, it was decided that California needed a long-term, basin-wide study of anadromous fish and their habitat.

"Only after the relationships between stream structure and fish productivity and diversity have been determined for an entire basin," says Lisle, "can we expect to verify positive and/or negative impacts of management on aquatic systems."

Debris: Not the menace once thought

Conventional wisdom is often proved wrong when scientists finally get around to applying the appropriate litmus test. No exception to this is the long-held belief that removing woody debris and other sizeable material from a streambed will enhance its productivity.

"Debris improves both the quality and quantity of fish habitat by providing cover and by varying stream velocity and depth," says Thomas E. Lisle, whose studies in Alaska and near Mount St. Helens have allowed him to conclude such structure as fallen trees, branches, rootwads, and boulders are a valuable commodity.

Lisle has also found that prey often shares the same reaches with predators because cover can be easily found in the patchy environment of a debris-strewn creek. During low flow in the summer, debris builds living space by damming the stream and by scouring pools.

In the Alaska study, Lisle's biologist co-workers compared fish populations in streams where logging debris was either left in or removed, to those from forested regions. They found that there were more fish and a greater diversity of fish in streams containing debris. Surprisingly, forested streams actually had fewer fish than those that had been logged.

Lisle speculates that debris helps sustain fish populations by keeping more water in the stream during the dry summers and by partitioning habitats so the fish do not see their neighbors.

"Debris jams also trap sediments and gravels that are important for spawning," he said.

Following the May 18, 1980 eruption of Mount St. Helens the question arose whether trees that had fallen across area streams in the wake of the blast but that still had commercial value should be harvested or left in. To answer the question, Lisle and his collaborators from PNW in Corvalis, studied 4 reaches and 12 subreaches. In some subreaches all material was removed, in others only merchantable trees were logged, while in still others the streams were left untouched. Just as in Alaska, they found that the reaches with the most debris had the greatest diversity and volume of habitat.

"It's hard to find a situation where there's too much debris," he said.

Lisle cautioned, however, that the short-term positive effects of these large introductions of debris into streams need to be viewed "with several grains of salt."

"The material that's in these streams now will begin to rot and wash away or get buried," he said. "At the same time the new trees growing up around the stream will not be large enough to produce replacement debris." He said that because of the later downturn in volumes of debris, he wouldn't be surprised to see a downturn in fish densities in these streams in the future, even below levels that are typical for forested streams.

Lisle sees merit in leaving debris in streambeds affected by logging or natural processes. "People have always had an urge to 'cleanse' a stream," he says, "but our studies suggest that such a move could be counter-productive."

Selecting the site

Choosing a suitable site in northern California was step one towards this goal.

"The basin had to have extensive habitat and enough fish to permit useful study," Lisle said. "We also wanted it to be typical of a large area in California."

Hurdygurdy Creek, a tributary of the South Fork of the Smith River in Six Rivers National Forest, satisfied most of the criteria.

"It's not in the Klamath-Trinity river basin so maybe it's not the best political choice," Lisle admitted, referring both to the perennial debate over who might be responsible for depleting fish populations in that basin and to the recent large influx of federal restoration money targeted for the Klamath and Trinity Rivers. But Lisle thinks Hurdygurdy is a good choice nonetheless, noting that it has the same geology and climate as the Klamath-Trinity basin. Besides, he said, "the large number of hatcheries in the Klamath-Trinity basin wouldn't make for a very clean study."

Assessing the stream habitats

The objectives for the PSW study are two-fold:

(1) to find out what sorts of habitats fish prefer at different stages of their life cycles and at different seasons of the year, and
(2) to define the physical processes that account for the formation of the various types of habitat.

Researchers map habitat units by plotting fish, boulders, water depth, and cover on grids.

One of Decker's jobs is to classify Hurdygurdy's many habitats.

"There are three types of riffles, two types of runs, and nine different types of pools. And those are all divided up by how flowing water creates the pools," she said, explaining the complexity of the scheme. Decker has identified 908 habitat types—or "units"—along Hurdygurdy's entire length. Representative habitats are then selected for detailed analyses and fish counts.

To do their field work Lisle and Decker, accompanied by three to twelve assistants, hike into the different reaches and measure the physical attributes of the selected units. Each unit is marked and measured for length, width, area, and volume. Some units are more thoroughly characterized by measuring thalweg and depth profiles, determining substrate type and relief, and by providing a detailed description of the site.

Lisle sees three types of channels in Hurdygurdy Creek. In order of increasing width, **confined channels** are bordered by bedrock, lack floodplains, and tend to be straight and narrow; **semi-alluvial channels** have floodplains along one bank, at least, and have single threads, **braided channels** split into multiple threads. These three types may be useful for classifying streams because they are common to many streams with gravel beds and could be easily recognized by fishery managers in the field or on aerial photographs.

The relative abundance of habitat types within the three channel types has already been determined. Confined channels have the greatest area of low-gradient riffles. Semi-alluvial channels, having the greatest areas in both cascades and pools, show the greatest diversity of habitat conditions. Braided channels have intermediate distributions of habitat units, but also have the greatest area of side channels which are important for winter habitat.

For analysis of fish distribution and abundance, the workers rely on bank-counting as well as underwater tallies.

"The best way to count fish," says Lisle, "is to put on a snorkle and mask and sneak up on them from downstream."

Seasonal effects

Also completed are the summer and fall counts for 1986. Although the data are just now being analyzed, it's Lisle's impression that, in the summer, young fish "are all over the stream" without showing an obvious preference for one area over another. "I don't know if it's density pressures or what," he says, "but all the fish are finding places to hang out."

As might be expected, the situation in winter is quite different.

During a couple of benchmark counts last winter, the researchers couldn't find fish anywhere in the main part of the stream; but after a thorough search they found fish "hiding" between rocks and other large structures. Lisle said that numerous fish were also spotted in backwater channels. Those beds, he explained, are formed on the floodplain and may not carry water at all in the summer, while in the winter they probably offer sanctuary from swift currents.

Decker said her first impression of the winter count is that there are fewer fish in general and a conspicuous absence of all but large Chinook. But she added that she will "continue to look through the winter to see whether the distribution and abundance of fish within these habitats changes."

Formation of fish habitats

Lisle, trained as a fluvial geomorphologist, is particularly interested in defining the physical processes that lead to habitat development.

Such things as landslides, structures in the streambed, sediment quality, stability of bars and banks, as well as the overall topography and geology of the creek basin may define what habitats are possible and how they are formed. Coming to terms with the physical forces that shape Hurdygurdy's creek bed may allow forest managers to anticipate habitat diversity and abundance in other similarly constituted streams without actually having to do costly field studies.

"Channels with common morphologies should have common relative abundances of habitat units," said Lisle.

Lisle has already described several principles that govern how obstructions affect channel behavior and hopes to study other streams in Northern California to see how variations in such factors as sediment size interact with these structures to form stream channels over various widths.

Lisle predicts that these same principles could then be used to anticipate the effects of sediment deposition in the stream from landslides, logging, and road erosion. The way such events affect the stream channel may be determined by the type of channel reached (e.g., braided, confined, obstructed, etc.).

Forest managers were faced with the choice of whether or not to salvage large trees toppled into channels around Mount St. Helens as a result of the blast of May 18, 1980.

The geomorphic study at Hurdygurdy Creek is being conducted in two phases. Already underway, is Phase One (part of the biological study), which is to relate habitat abundance to the various physical characteristics of the channel. The volume of pools, for instance, is likely to depend both on the size of obstructions, which intensify the scouring force of water, as well as sediment type, which controls the depth of scour. The number of pools, on the other hand, is expected to relate to the frequency of channel obstructions and to "sinuosity," a measure of a river's twists and turns.

Phase Two, to commence this summer, will address possible cause and effect relationships between the geomorphic characteristics of Hurdygurdy Creek and its habitat profile.

At the completion of the first two phases of the study, the geomorphic and biological data will be compared in an attempt to divine the individual and collective contributions of such factors as channel width, bed material size, stream gradient, and the presence or absence of bars, landslides, and debris on habitat type and numbers of fish.

"There is no definite cut-off date for the study," said Lisle, who anticipates that as more is learned about Hurdygurdy Creek, new questions will arise that will beg to be answered. Already, some differences between his and the basin studies in Oregon and Washington have been noted. For one thing, the Chinook salmon in Hurdygurdy Creek migrate farther into the basin and stay longer in the smaller streams. "Before now it has been commonly thought that young Chinook migrate out to a river's estuary within a few months of hatching," Lisle said. "But we're finding that they stay in Hurdygurdy Creek much longer than that and we would like to find out what keeps them there."

Eventually Lisle and Decker want to place a trap at the bottom of the stream so that fish can be systematically counted, weighed, measured, and tagged. "In this way we should be able to determine the number of fish migrating to sea and, therefore, the overall productivity of the basin." Lisle observed that it makes little difference if fish are able to reach a stream to spawn and lay eggs if the young fail to grow up, migrate to sea, and mature."

The Hurdygurdy study promises to yield many such valuable insights into the life of a Northern California stream. Lisle and Decker invite scientists from other agencies, universities, and industry to work with them in this natural laboratory in the Klamath mountain range.

Helping bald eagles keep a foothold in the Southwest

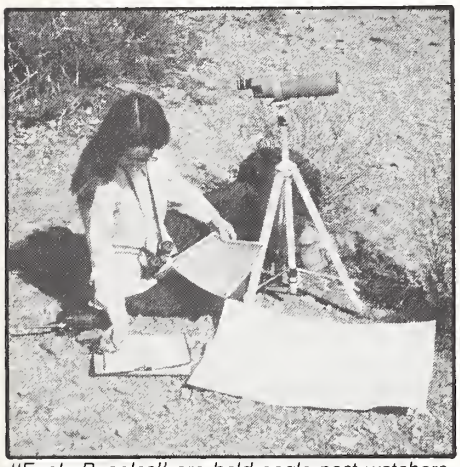
by Rick Fletcher
Rocky Mountain Station

These 7-week-old eaglets are perched at a typical cliff nest location along the Salt River in Arizona.

"Unfortunately this nest was very poorly built. Loosely constructed on a slanting ledge, it had a prickly pear pad supporting the front of it. The nest is very accessible and both young were lost to predation. We think it was probably a bobcat or a coyote. During the non-breeding season last summer, we went in and constructed an artificial nest, though you wouldn't know from the outward appearance. We found a column on the same cliff that is basically impenetrable to mammalian predation. It's 12 feet from the top of the cliff face down to the nest, and about 70 to the slope below. However, this year, the birds went back to their traditional nest. We hated to see that. Presently the controlling agencies are deciding if it would be wise to relocate the young birds if hatching occurs again. When they're 2 or 3 weeks old, they could be placed in a more secure, protected nest. At least we could remove the possibility of mammalian predation."

Research Wildlife Biologist Terry Grubb discusses some of the successes and disappointments of the past 10 years of studying bald eagles in the Southwest. Since 1983 the Rocky Mountain Station has had the lead responsibility for coordinating and conducting bald eagle research, most recently on the breeding population, in central Arizona. Early research efforts focused primarily on winter habitat needs—feeding habits, behavior, roosts, perches, etc. However, a 3-year breeding study has just been completed.

Although some eagles overwinter in New Mexico, Arizona is the site of several year-round breeding pairs. "It surprises most folks to think that the cactus-covered desert Southwest is home to bald eagles," said Grubb. "Even after being here for a number of years, I still find it hard to get used to seeing a saguaro and eagle side-by-side."



"Eagle Beagles" are bald eagle nest watchers that help provide nest site protection and collect scientific data.

With a couple of exceptions, virtually all of the nesting sites are on the Salt and Verde River systems in the central part of the State. Eagles are associated with the riparian areas of the state, where there is often conflict between livestock, recreation, and wildlife interests. The birds tend to nest on cliffs, ledges, or pinnacles. Snags are also a favored spot. Egg-laying occurs early, from mid-January to mid-February. This allows the young to fledge prior to the summer heat.

"In 1984-85, we had 18 known breeding areas within Arizona," said Grubb. "We found 4 new ones last year, 2 of which were definitely new nests and presumably new pairs. There's been a very significant increase in successfully fledged young. In 1981, we doubled the average of 5 to 7 young per year out of 3 or 4 nests to 14. We dropped to 13 in 1982, went to 15 in 1984, and hit an all time record of 22 young from 13 nests in 1985. There's a variety of possible reasons, but we would like to think it is largely a result of our intensive coverage, surveillance, and protective management actions that led to the increased population," he said.

Eagle beagles

Perhaps one of the most important reasons for the success of this research effort can be attributed to the "eagle beagles"—a volunteer bald eagle nest watcher program that dates back to 1978. The program was established on Arizona National Forests to help prevent excessive human disturbance at nest sites, and later broadened to study eagle and human activity in and around bald eagle breeding areas. From a modest beginning on a single Forest with just 1 Audubon Society volunteer to monitor 1 nest, the program has expanded to other National Forests, and into a large-scale site monitoring operation with several full-time, well-trained volunteers. "Today," said Grubb, "these people not only assist with site protection, but they collect extensive biological data, from nest repair to post-fledging dispersal." Typically 1, or preferrably 2, people are stationed on a strategic ridge or cliff overlooking an area where they can record eagle activities and movements. One of the main objectives is to map geographic units for management purposes based on habitat use by the nesting eagles. Another objective is to identify and correct disturbing activities in these areas. Seasonal closures to human activity have been used in conjunction with the nest watch program to achieve this goal.

"About three-fourths of the known bald eagle breeding areas are on National Forests, and all of these are monitored under the nest watch program. I can't emphasize enough the importance of these volunteers to our studies" said Grubb.

Study focus

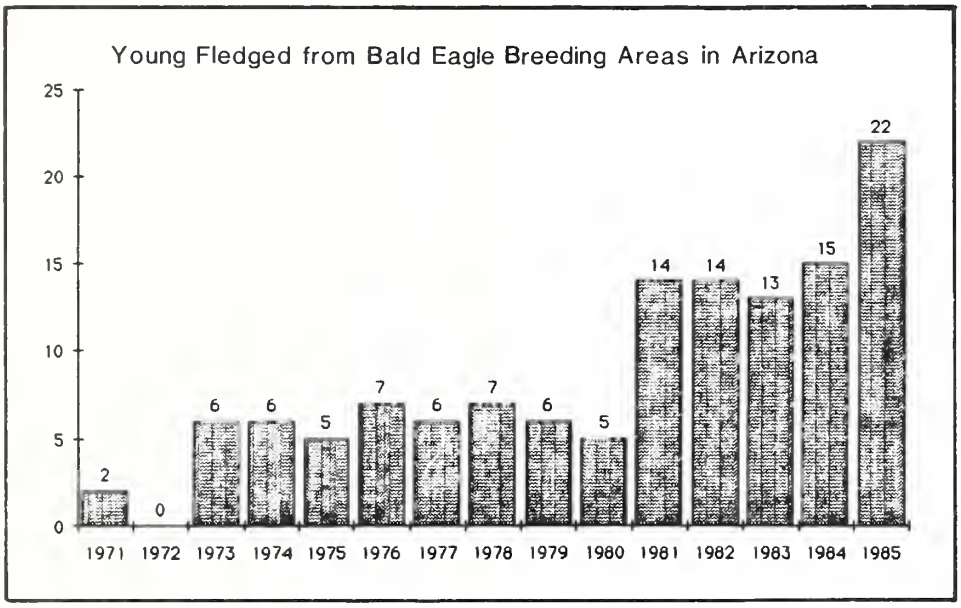
"I've been studying bald eagles in Arizona for about 10 years now," says Grubb, "and I must admit that we feel like we have a pretty good idea of what's going on with the population here. And yet, each year something unusual, something unexpected, something that never happened before comes up. Nonetheless, such occurrences are one of the things that make bald eagles exciting to study."

Major areas of research for Grubb and his associates include:

1) food habits and foraging areas—what the eagles are eating and where they are getting their food; and

2) human disturbances and nest manipulations.

One of the surprise findings is that, while 53 percent of the bird's diet is fish, a substantial part is made up of mammals. And, the varability of the diet during different months surprised researchers. In February, about 80 percent of the diet at some nest sites is mammals. By March, fish make up the bulk of the menu, as mammals account for only 15 to 20 percent. "We believe this relates to a change in streamflow and weather," said Grubb. "By late spring, streamflows stabilize, the water clears, and fish become more available."



Since 1981, productivity for Arizona bald eagles has doubled. A significant portion of this success is directly attributable to Forest Service research and management efforts.

Bald eagles forage primarily in the early morning and late afternoon. However, scientists observed one breeding pair that foraged only during the morning, and attribute it to a high level of human activity along the river in the afternoon. "One of the important realizations to come out of this is that one must look at the individual nest and circumstance, and not rely solely on population averages," said Grubb.

Bird botherings

A great deal of research involved how eagles react to human disturbances. Different classes of disturbances and the eagles' response to them—from nonrestless, to flight, to leaving the area—were considered. Scientists found 250 yards to be the average distance to disturbances which caused the birds to fly. At 200 yards, they leave the area.

"The most intriguing aspect of disturbance and management requirements," says Grubb, "is the pre-season or pre-egg laying activity. Observations so far indicate that early in the season, when the eagles spend the least time at the nest, may be the most sensitive time—the period when the birds are the most easily disturbed off the nest."

Fostering and nest manipulation

Two efforts to help improve nesting sites and fledging success involve fostering young, and repairing or building nests. Fostering has been a real success for the researchers. The first attempt occurred when two young were rescued from a nest being inundated by flood waters. The one-week-old chicks were placed in an incubator and fed through an eagle puppet at the Phoenix, Arizona zoo. Meanwhile, another pair of eagles had incubated well past the normal period with no signs of hatching. Scientists replaced the 2 addled eggs with the now 2-week-old chicks. Within 20 minutes, the adults were back at the nest feeding and brooding the young. Other fostering efforts have met with similar success.

Over the past few years, several man-made nests have been constructed to replace fallen nests or to encourage nesting in areas lacking good natural nesting sites. "Eagles don't always build their nests in safe and secure spots," says Grubb. "They may be in a flood plain and subject to high water, or built in rotten snags that are ready to topple.

Construction of artificial nests has been a useful management tool in increasing nesting success and productivity.

One inexperienced pair built where predators had easy access to eggs and chicks. What we've done is build more secure nests using old nesting and other natural materials—a very tedious and time-consuming task. Other nest manipulations have involved designing and building tripod-like artificial nest support structures made of aluminum pipe, attaching shading structures to nests to protect young from the searing summer heat, and using explosives to enlarge a too-small cliff cavity used for nesting."

Since 1977, 6 of 9 artificial or manipulated nests were actively used by breeding adults the following year. Four of these successfully produced young.

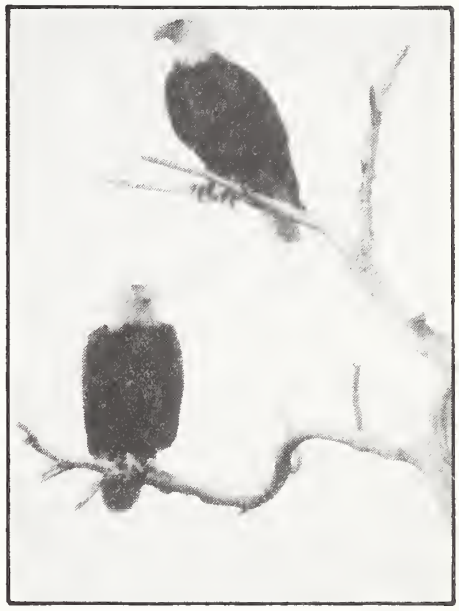
Management concerns

Grubb says there are important management implications concerning studying bald eagles in Arizona. "With such a small, isolated population, it seemingly makes little difference whether the operative word in management direction is maintenance or recovery; either way there is justifiable cause for concern and intensive management," he said.

A variety of techniques have been applied to these birds in the name of increasing fledging success. Some have been successful, while others remain unproven. But always there remains the question of "how much is enough?"

Small, endangered populations provide arguments for and against manipulative management. Because numbers are so small, some argue that the birds should be left alone and spared the risks of "hands-on" research. Others argue that the small numbers themselves justify innovative, sometimes drastic, manipulative measures. The general philosophy for bald eagle research/management in Arizona has been somewhere between the two philosophies, with perhaps an inclination toward manipulation.

A related question concerns the risks and benefits of studying 100 percent of a small population. "Passive, undisturbing activity is one thing," says Grubb, "but hands-on, manipulative



This adult pair of breeding bald eagles are believed to be year-round residents. Courtship and nest repair typically occurs in late fall, and eggs are laid by February.

work has been questioned and is now limited. Leaving some breeding areas alone provides for experimental control, as well as allowing for a natural safeguard in case the applied techniques have a detrimental effect."

Grubb explains, "In the endeavor to study or help a species, it is always possible to overdo or lose perspective. For instance, a particular manipulation may allow individuals to survive, but fosters characteristics detrimental to the population's overall fitness. For these reasons it is wise to periodically step back to review past, present, and future management and research efforts for the recovery program, and constantly evaluate how much of such efforts to permit before allowing the species or population to fend for itself."

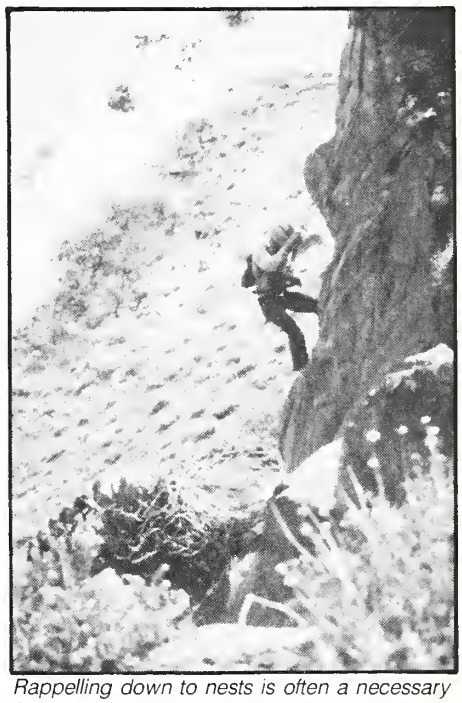
Despite the problems and ever-present reservations against excessive intervention, much of what the scientists have done in behalf of Arizona's small breeding population has been well worthwhile. The nest watch program has not only been instrumental in educating the public and enforcing nest site closures, but it has also contributed significantly to the collection of useful biological data.

The artificial nests and nest modifications have been remarkably successful. Permanent, flood-resistant structures are now available in a territory that has always had problems with nest tree loss. In addition, as such techniques are tested and refined, the potential for supplementing marginal habitat or moving the eagles to more suitable habitat increases. It often takes bald eagles several years to accept and use artificial nest structures, so application of these techniques requires both insight into the resource needs, and patience.

In summation, Grubb states, "It is hoped that through the careful pursuit of such research programs, the information necessary for effective management can be obtained while minimizing or eliminating any negative impact on the eagles. There is no definitive answer to 'how much intervention is enough?', but through definition and prioritization of objectives, through careful, scientific application of proven field techniques, and through continuing coordinated program reassessment, it is possible to achieve sound bald eagle management in the Southwest."

The Station's bald eagle research is part of a cooperative, multi-agency assessment of research and management priorities for Arizona's breeding bald eagles, under the direction of the U.S. Fish and Wildlife Service, and the Southwestern Bald Eagle Recovery Team. The ultimate objective is to recover the population to a point that it can be delisted from its current endangered status.

For more information on bald eagle research in the Southwest, contact Terry Grubb at the Forestry Sciences Laboratory, Arizona State University, Tempe, Arizona, 85287, (602) 261-4365, FTS-261-4365.



Rappelling down to nests is often a necessary feat in order to study the young, measure nests, and collect prey remains, addled eggs and eggshell fragments.

New publications

The LOGS Study: Twenty-year results

In 1962, representatives of State, Federal, and industrial forestry organizations began an international cooperative effort to determine how the amount of growing stock retained in repeatedly thinned young stands of Douglas-fir affects cumulative wood production, tree size, and ratios of growth to growing stock. At the time the study was started, it was commonly thought that if amounts of growing stock differed, volume growth per acre would not vary much, although the size of trees produced would be affected.

Results now show that the number of trees left per acre does affect the total volume of wood produced, as well as average tree size. Volume increments is strongly related to growing stock, under the conditions represented in the LOGS studies. Relatively high stand density is required for high cubic-volume production. Conversely, diameter increment declines with increasing stand density.

The study plan, which examines cumulative wood production, tree size development and growth-to-growing stock ratios under eight different thinning regimes, was initially developed at Weyerhaeuser Company, Centralia, Washington. Procedural details for maintaining consistency among the cooperators were developed by PNW Station, according to report authors Robert O. Curtis and David D. Marshall.

The LOGS study consisted of nine field installations established in Oregon, Washington, and British Columbia. This 20-year report is a joint effort by the cooperators and provides a general description of the LOGS program, some comparisons of results between the installations, and some generalizations and discussions of implications. According to the authors, these comparisons are "necessarily incomplete, because the studies have not yet run their full course, and because not all analyses of interest can be included in a single report."

The most productive future use of the LOGS data—and the most effective means of applying these results to practical management—will probably be in constructing and refining stand simulators. The LOGS studies provide a unique set of high quality data from young stands maintained at relatively low densities. Information on stands of this type is crucial for evaluating stand management regimes for our future forests. Very little other information of this sort is currently available. The LOGS report provides basic information on relationships between growth and growing stock in such stands.

For a copy of *The Level-of-Growing Stock Cooperative Study in Douglas-fir: Report No. 8, The LOGS Study; Twenty-Year Results*, request Research Paper PNW-356 from the Pacific Northwest Station.

A succession model for managers

A great many models have been developed to depict forest succession. While each of these has met a particular need, none has allowed resource managers to easily predict vegetation response to alternative management treatments.

Scientists at the Intermountain Station's Forestry Sciences Laboratory in Missoula, MT, have addressed this need. In a new report, Research Forester Steve Arno, and others, outlines a method to model succession within a habitat type, and to predict the type of vegetation that will develop after different management activities.

Intended for use in land management and in planning, the approach produces a general-purpose ecological classification of seral community types on a given habitat type. It also serves as a guide to help users confirm the habitat type of seral stands.

Request *Characterizing Succession Within a Forest Habitat Type—An Approach Designed for Resource Managers*, RN-INT-357.

Regenerating Engelmann spruce

Prompt establishment of Englemann spruce natural reproduction following clearcutting is a major obstacle in managing spruce-subalpine fir forests in the central Rockies. However, scientists at the Rocky Mountain Station have recently developed several guidelines that will help foresters overcome barriers to natural regeneration.

Research findings indicate that in the Engelmann spruce habitat type, shaded, mechanically scarified, mineral soil seedbeds on north aspects can be adequately restocked naturally within a 5-year period in clearcut openings 300 to 450 feet wide. With shade or scarification alone, size of opening that will restock is reduced to 200 to 350 feet. The effective seeding distance is so limited on unshaded natural seedbeds on north aspects and on south aspects regardless of the seedbed conditions that the expectation of natural restocking in a reasonable period of time with clearcutting is not a realistic option.

Details on this study can be found in *Engelmann Spruce Seed Production and Dispersal, and Seedling Establishment in the Central Rocky Mountains*, General Technical Report RM-134. Copies are available from the Rocky Mountain Station.

—Number of viable seeds required to produce 800 5-year-old Engelmann spruce seedlings per acre in relation to seedbed treatment and aspect.[1]

Seedbed treatments	Aspect	
	North	South
Scarified shaded	25,600	272,800
Scarified unshaded	60,800	∞[2]
Unscarified shaded	57,600	249,600
Unscarified unshaded	333,000	∞

[1]*Data presented are based upon the exclusion of seed-eating mammals. If these animals are not excluded, numbers of seed required should be increased by 100%.*

[2]∞ = *no survival.*

All streams are not created equal

All stream sections are not created equal when it comes to accurately estimating fish populations, according to David G. Hankin, author of *Sampling Designs for Estimating the Total Number of Fish in Small Streams*.

A common two-stage sampling approach often used in freshwater fisheries begins with selecting a sample of stream sections, usually of equal length.

Next, the total number of fish in each selected section is estimated and extrapolated to the entire stream.

According to Hankin, this conventional practice of selecting stream sections can result in errors. Errors in estimating fish numbers within the sample areas will be small, however, compared to errors resulting from expanding the sampled areas to represent a whole stream, he says. Fish numbers are strongly related to habitat type; the "equal stream lengths" technique does not take this correlation into account. Greater accuracy can be obtained by making the sampled sections correspond to natural habitat units such as pools or riffles, so sampling designs can take advantage of the natural correlation between habitat and numbers.

Hankin describes and contrasts three alternative two-stage sampling techniques that allow substantially increased precision in estimates of the total number of fish in small streams. He also discusses determination of the best choice among the alternative designs, considering relative performance, cost, and cost-effectiveness.

This paper also provides users with some basic background information on sampling design, but is designed so readers with more sophisticated knowledge can skip that section.

For a copy of *Sampling Designs for Estimating the Total Number of Fish in Small Streams*, request Research Paper PNW-360 from the Pacific Northwest Station.

Wilderness research conference proceedings available

Scientists and managers from throughout North America gathered in Fort Collins, CO, in July of 1985 to participate in a National Wilderness Research Conference.

Over 70 reports of current wilderness research presented at the conference are contained in a new INT report. The papers are grouped into nine wilderness topics: fire, air quality, impacts to soil and vegetation, impacts to fish and wildlife, impacts to water, recreational use and user characteristics, attitudes and behavior, wilderness benefits, and wilderness management concepts and tools.

The new report will assist those planning future wilderness research in selecting problems to study and in developing research designs. Wilderness managers will be interested in many of the reported research results in formulating programs to protect wilderness resources and in providing quality visitor experiences.

Work is currently under way on a second volume containing "state-of-knowledge" review papers by wilderness agency heads and leading scientists.

Request *Proceedings—National Wilderness Research Conference: Current Research*, GTR-INT-212.

Two new publications on Alder

Forest managers need site-specific information on site quality to make intelligent decisions on species selection and management practices. The most commonly used measure of potential site productivity is site index (mean height of crown class trees that have been free to grow in an even-aged stand at a specified age).

In *A Method of Site Quality Evaluation For Red Alder*, PNW Station Researcher Constance A. Harrington has developed an accurate field guide for predicting site index for red alder in stands in western Washington and northern Oregon. The guide requires users to evaluate 14 soil-site properties grouped in three general categories: geographic and topographic position; soil moisture and aeration during the growing season; and soil fertility and physical condition.

The guide was developed using techniques devised for site evaluation for several southern hardwoods, though it differs from those models in placing considerable importance on the actual location or position of the site to be evaluated. One of the goals of the project was to provide a field guide for site evaluation that could be used by practicing foresters. Thus, when possible (without reducing accuracy) soil-site properties selected for use in the model were those that could be determined with a minimum of special equipment.

The site evaluation tables in this publication were developed from natural, unmanaged stands west of the crest of the Cascade Range in Washington and northern Oregon, and should not be used outside this geographic area until local users determine the applicability of the tables to their site conditions.

The publication contains the site evaluation tables and a sample field worksheet. For a copy, request General Technical Report PNW-192 from the Pacific Northwest Station.

Height Growth and Site Index Curves for Red Alder by Constance A. Harrington and Robert O. Curtis presents new polymorphic height growth and site index curves developed for red alder using a reference age of 20 years.

The curves are applicable to natural stands between 5 and 50 years of age in western Washington and northwestern Oregon. They provide a better fit with observed patterns of height growth than those previously available. The new curves should be an improvement, particularly for use in short-rotation management.

The new curves for estimating height growth and site index were developed using stem-data analysis from two sources: new data from 23 natural stands in western Oregon and Washington, and previously published data from western Washington. The new curves are recommended over previous curves because they are based on a much larger sample of trees covering a greater geographic range and a somewhat greater range in site index; the reference age of 20 years is more appropriate to future short rotation management of the species than the 50 years formerly used; and the more flexible growth function used in the new curves provides a better expression of observed height growth trends.

The site index estimation curves, rather than the height growth curves, are recommended for use in estimating site index (S20).

For more information, request Research Paper PNW-358 from the Pacific Northwest Station.

PROGNOSIS—version 5.0

PROGNOSIS, the computer model intended to simulate the development of forest stands, was designed so that it could be updated as improvements were developed. Since the model was released in 1981, scientists at the Intermountain Station's Forestry Sciences Laboratory in Moscow, ID, have been developing new routines and refining existing models that make PROGNOSIS a more powerful and accurate tool.

A new INT report describes changes in existing features of the model, new program options, and changes in the program's output. Version 5.0 of the PROGNOSIS model includes:

- a regeneration establishment model,
- small-tree increment model revisions,
- an addition to the COVER model that predicts shrub development and total canopy cover,
- New management options,
- an Event Monitor for scheduling management activities,
- more efficient growth prediction methods,
- numerous improvements in the biological models.

Request *Supplement to the User's Guide for the Stand Prognosis Model —Version 5.0*, GTR-INT-208, by William Wykoff.

Managing wilderness campsites

A new INT report suggests that managers concerned about deteriorating wilderness campsites concentrate their efforts in areas where use levels and impacts are currently low. These sensitive areas will either rapidly recover—or deteriorate—in response to management actions, according to ecologist David Cole.

Cole studied ecological changes on 22 campsites in the Eagle Cap Wilderness. He found that heavily used, deteriorated campsites require many decades to recover—and may never recover if compliance with closure is poor. They are not likely to deteriorate or improve substantially in a short time, regardless what managers do.

This suggests, according to the report, that in attempting to avoid campsite deterioration, a high priority should be placed on management of campsites and destination areas that are receiving relatively low but consistent amounts of use. Cole recommends that managers try to maintain use levels on low-impact areas, avoid consistent use of the same campsites, and discourage high-impact types of use, such as large group camping.

Copies of *Ecological Changes on Campsites in the Eagle Cap Wilderness, 1979 to 1984*, RP-INT-368, by David N. Cole are available from the Intermountain Research Station.

Eat "Hobble Creek" for an enriched sagebrush diet

Mule deer and domestic livestock need high-energy, nutritious food, especially on winter ranges that traditionally support forage plants having nutrient levels below maintenance requirements of animals.

Scientists at the Intermountain Station's Shrub Sciences Laboratory, in collaboration with the Utah Division of Wildlife Resources, have released a genetically improved low-elevation mountain sagebrush—the 'Hobble Creek' selection—that should help prevent loss of animal weight in deer and livestock that feed on winter ranges. The 'Hobble Creek' sagebrush exceeds typical winter forage values in amount of energy-producing compounds, crude protein, phosphorus, and carotene. Two other characteristics make this sagebrush a desirable winter range shrub. It does not contain substances that lower grass cell wall digestion in ruminant animals. Better yet, the grazing animals—both mule deer and sheep—seem to prefer this plant over others.

Information on the history, nutritive profile, and methods of planting, handling, and establishing this plant is provided in a new INT research paper. For your copy, request *"Hobble Creek"—A Superior Selection of Low-Elevation Mountain Big Sagebrush*, Research Paper INT-370, by Bruce Welch and others.

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Please send the following Pacific Northwest Station publications:

- ☐ *The Level-of-Growing Stock Cooperative Study in Douglas-fir: Report No. 8, the LOGS Study; Twenty-year Results*, Research Paper PNW-356.
- ☐ *A Method of Site Quality Evaluation for Red Alder*, General Technical Report PNW-192.
- ☐ *Height Growth and Site Index Curves for Red Alder*, Research Paper PNW-358.
- ☐ *Sampling Designs for Estimating the Total Number of Fish in Small Streams*, Research Paper PNW-360.
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Please send the following Rocky Mountain Station publications:

- ☐ *Engelmann Spruce Seed Production and Dispersal, and Seedling Establishment in the Central Rocky Mountains*, General Technical Report RM-134.
- ☐ *Range Forage Data Base for 20 Great Plains, Southern, and Western States*, General Technical Report RM-133.
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- ☐ *Supplement to the User's Guide for the Stand Prognosis Model—Version 5.0*, General Technical Report INT-208.
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- ☐ *Ecological Changes on Campsites in the Eagle Cap Wilderness, 1979 to 1984*, Research Paper INT-368.
- ☐ *Characterizing Succession Within a Forest Habitat Type—An Approach Designed for Resource Managers*, Research Note INT-357.
- ☐ *"Hobble Creek"—A Superior Selection of Low-Elevation Mountain Big Sagebrush*, Research Paper INT-370.
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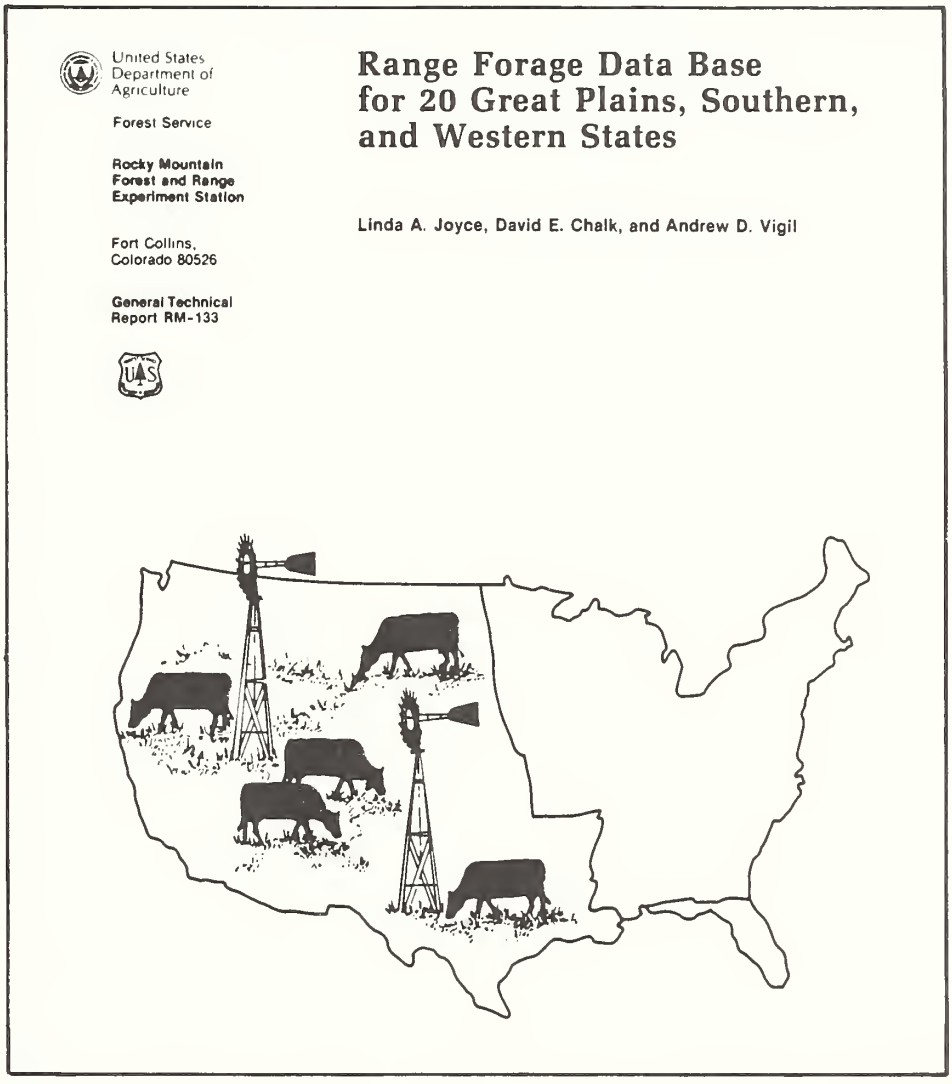
Range forage data base now available

A new report has been issued by the Rocky Mountain Station that describes the content and accessibility of a rangeland data set based on the Soil Conservation Service (SCS) Range Site Description.

A range site is an ecological subdivision of the landscape based on the ability of that site to produce a characteristic natural plant community. Range Site Descriptions were developed by the SCS to help plan and carry out resource conservation programs on rangeland and other native grazing land.

Previously, Range Site Descriptions were available within each state SCS office in written form only. Now, the information has been extracted and placed on computer under the program name RANGE FORAGE. The data set contains information taken from all SCS Range Site Descriptions for 20 states: Arkansas, Arizona, California, Colorado, Florida, Idaho, Louisiana, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. All files are stored on tape at the USDA Computer Center in Fort Collins, Colorado.

For a copy of the publication, request *Range Forage Data Base for 20 Great Plains, Southern, and Western States*, General Technical Report RM-133, available from the Rocky Mountain Station.



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